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(71) Applicant *(for all designated States except US)*: ALLGON AB [SE/SE]; P.O. Box 500, S-184 25 Åkersberga (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: YIDONG HU, Annika [CN/SE]; Bivägen 103, S-184 38 Åkersberga (SE).

(74) Agents: ESTREEN, Lars et al.; Kransell & Wennborg AB, Box 27834, S-115 93 Stockholm (SE).

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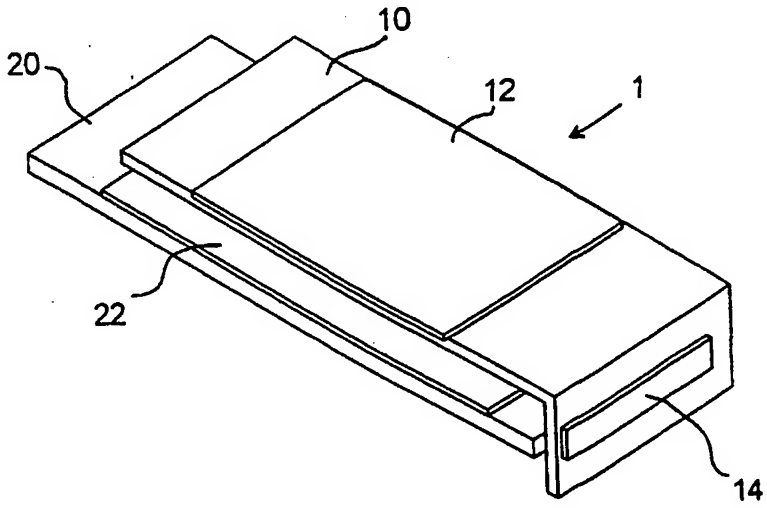
(54) Title: AN ANTENNA DEVICE, A COMMUNICATION DEVICE COMPRISING SUCH AN ANTENNA DEVICE AND A METHOD OF OPERATING THE COMMUNICATION DEVICE



(57) Abstract: An antenna device comprises a first (12) and a second (14) internal antenna element and a common ground plane (22). The first element comprises an upper and a lower end portion. The first antenna element is adapted for use with a cellular mobile phone system and the second one for use with a GPS system. To that end, the second element is elongated and adapted to receive circularly polarized radio signals by operation with linear polarization. This provides for a compact antenna device adapted for use with more than one communication system.

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AN ANTENNA DEVICE, A COMMUNICATION DEVICE COMPRISING SUCH AN ANTENNA DEVICE AND A METHOD OF OPERATING THE COMMUNICATION DEVICE

FIELD OF INVENTION

The present invention relates generally to an antenna device and more particularly to a combined antenna device including an internal GPS antenna and at least one internal antenna for cellular radio communication.

BACKGROUND

The use of GPS (Global Positioning System) for determining the position of a terminal is increasing. GPS typically uses electromagnetic waves with circular polarization and a center frequency of 1,575 GHz. Today, the terminal is almost always a dedicated GPS terminal with an antenna arrangement adapted for GPS communication. This usually means a patch or quadrifilar helical antenna.

However, these types of antennas occupy a large space, especially the helical antenna. Also, a patch antenna has a considerable extension in two dimensions, making it difficult to place on a small substrate. It also requires a ground plane separated from the patch and being larger than the patch element.

The use of mobile phones and multi-purpose communication devices is increasing. Among the cellular mobile phone systems in use today can be mentioned the GSM system, using linearly polarized electromagnetic waves belonging to frequency bands of 900, 1800 or 1900 MHz, and the CDMA, JPC and AMPS systems.

There is a desire to integrate the functions of the GPS and the mobile phone systems into one terminal, i.e., a hand-portable radio communication device with a GPS function as well. However, the compact nature of a mobile phone poses special problems when designing the antenna arrangement adapted for use with both systems.

It is previously known antenna arrangements comprising a vehicle antenna for satellite navigation and for mobile radio communication. US 5,706,015 discloses an arrangement comprising both a GPS antenna and an antenna working in the GSM bands. However, this arrangement is a flat-topped antenna apparatus intended for arrangement on a conducting surface. The radiating and receiving elements of the different antennas are arranged essentially parallel to each other and in different planes.

EP 0 895 299 discloses a radio communication device comprising a conventional cellular antenna and a GPS antenna in the form of a helical antenna placed in an elongated antenna holder resembling a conventional rod antenna. The helical antenna is spaced apart from the terminal body by means of a communicating section in the antenna holder. In an alternative embodiment, this document discloses a patch-like antenna element in the upper part of the terminal body mounted on a flat substrate. On the underside of the substrate is a ground plane for the patch-like antenna element. This configuration is not suited for use with a portable radio communication device, such as a mobile phone, due to its space-demanding configuration.

The US patent 5,929,812 discloses a mobile antenna with an optional patch antenna for higher frequencies. This configuration is limited to use with a vehicle.

The US patent 5,444,452 discloses an antenna apparatus for receiving GPS signals of two distinct frequencies. An antenna device for use in a cellular mobile network is not described.

The European patent publication EP 0 821 428 A2 discloses a portable radio communication apparatus for satellite communication. The combination of an internal mobile phone antenna and GPS antenna is not described.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a compact antenna device comprising both an antenna for circularly polarized electromagnetic waves, such as for the GPS system, and at least one antenna for linearly polarized electromagnetic waves, such as for cellular mobile telephone systems.

Another object is to provide a radio communication device incorporating an antenna arrangement operating both with linearly and circularly polarized radio signals.

Still another object is to provide a method of operating a portable radio communication device having a first and a second antenna element.

The invention is based on the realization that an elongated element can be used as an antenna for receiving circularly polarized electromagnetic waves, such as those used in the GPS system, and that a common ground

plane can be used for antennas operating with different kinds of polarization.

According to the present invention there is provided an antenna device as defined in claim 1.

This provides for a compact antenna device adapted for use with more than one communication system.

According to the present invention there is also provided a portable radio communication device comprising such an antenna device as defined in claim 17 and a method of operating such a portable radio communication device as defined in claim 20.

Further preferred embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF DRAWINGS

The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of an antenna device according to the invention;

Fig. 2 is an elevation view of the device of fig. 1;

Fig. 3 is an end view of the device of fig. 1; and

Fig. 4 is a plan view of the device of fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

In the following, a detailed description of a preferred embodiment will be given. In this disclosure it is to be understood that the antenna device of the invention is operable to transmit and/or receive RF signals. Even

if a term is used herein that suggests one specific signal direction it is to be appreciated that such a situation can cover that signal direction and/or its reverse, unless specifically stated otherwise.

Figure 1 shows the antenna device 1 comprising a member 10 for supporting radiating elements, see below. The member 10 is generally flat dielectric support and is provided with a folding giving it a shape resembling an L when viewed from the side, see figure 2. Mounting elements (not shown) are provided for attaching the member 10 to a generally planar PCB 20 of a portable radio communication device, such as a portable mobile phone. The PCB 20 is provided with relatively large conducting portions functioning as a ground plane 22 of the antenna device. The ground plane is provided with an upper end portion 22a and a lower end portion 22b, see figure 2. The references to "upper" and "lower" refer to the general orientation of the device during operation.

The upper surface of the device 10 as seen in figure 1 is provided with a conducting layer 12 functioning as a first radiating and receiving element of a cellular mobile phone antenna, the ground plane thereof being the ground plane 22. The layer 12 is provided with an upper end portion 12a and a lower end portion 12b, see figure 2. The conducting layer 12 and the ground plane 22 are positioned in essentially mutually parallel planes and separated by a predetermined distance d1. The conducting layer 12 has a feed portion (not shown) and is connected to the ground plane by means of ground connection elements (not shown), thereby constituting a so called PIFA (Planar Inverted F Antenna).

The folded portion of the member 10 comprises a rectangular substrate on which a second element in the form of conducting layer 14 is provided. The element 14 has an elongated shape and is provided with a feed element (not shown) at one end thereof.

The second element 14 is provided at a distance d3 from the upper end portion 12a of the first element 12. The mutual distances of the first and second radiating elements 12, 14 and the ground plane 22 are of vital importance for the performance of the antenna device. Thus, it is preferred that the distance d1 between the ground plane 22 and the first element 12 is shorter than the distance d3 between the first and second elements 12, 14. Also, it is preferred that the distance d2 between the ground plane and the second element 14 is shorter than the distance d3 between the two radiating elements 12, 14.

Despite the shape of the layer 14 it has surprisingly been found that it functions well as a receiving GPS antenna element, i.e., as an element for receiving circularly polarized waves. As is seen in figure 2, the element 14 is positioned essentially in the plane of the ground plane 22 and at a predetermined distance d2 therefrom. Also, the element 14, being essentially strip shaped, is positioned essentially perpendicular to the ground plane 22. A suitable mutual distance d2 of the ground plane 22 and the second element 14 is about 7-9 mm. Thus, the GPS antenna uses this layer 22 as the ground plane. This positioning has found to provide particularly good characteristics for the GPS antenna.

It is to be appreciated that the second element 14 is unable to transmit circularly polarized waves with the configuration described herein. However, this is not a problem in the particular application of GPS, as this only involves communication in one direction, i.e., reception of incoming waves. The GPS information can be used for example in an emergency situation wherein an emergency call can automatically transmit the position of the phone to an emergency central.

The overall shape of the housing 30 of a radio communication device or terminal, such as a mobile phone, is shown by broken lines in figure 4, which is a plan view of the back side of the device, i.e., the side pointing away from the user when in operation. The terminal is provided with a keypad (not shown) functioning as a user interface.

The antenna device is positioned in the upper portion of the terminal when in a preferred operating position, in this case the right hand portion as shown in figure 4. This provides for a position of the element 14 that is particularly suitable in connection with satellite communication, because the user will point generally upward with the antenna element portion of the terminal when using the terminal. Thus, in GPS operation the antenna device is oriented with the upper end portion 22a of the ground plane 22 pointing generally upwards and with the GPS antenna element 14 being positioned above the ground plane by the distance d2.

The length of the element 14 is adapted to the frequency of the GPS system, i.e., 1,575 GHz. In the preferred embodiment shown, the length is one quarter of

the length of the wave, i.e., the GPS antenna is a so-called quarter wave antenna with a length of approximately 5 cm for the GPS system. It should be noted that this length refers to the total effective length from the feed point of the element 14.

The device 1 is provided with separate feed points for the elements 12 and 14. Thus, the function can be switched between the two antennas, depending on the desired application. The two antennas can also be in use simultaneously.

The above described embodiment provides an antenna device which is compact, easy to manufacture and easy to assemble. Both the height and the width of the device can be made to fit in a modern compact size mobile phone.

It is realized that the antenna device according to the invention can be varied within the scope defined by the appended claims. Thus, the radiating and receiving elements have been shown with specific shapes. It is realized that they can have any suitable shape adapted for the specific requirements on the antenna element in question. Thus, although the first antenna element 22 has been shown with a generally planar shape, it is realized that it can be slightly arched, thereby being adapted to the overall shape of the cover in which the antenna device is mounted.

A PIFA has been described with the preferred embodiment. It is to be understood that the antenna 12, 22 for linearly polarized electromagnetic waves can be any suitable antenna configuration, and includes a radiat-

ing element such as a patch element or a meander shaped element or it is a modified PIFA or a micro strip antenna in general. Thus, the antenna 12, 22 can be any antenna device suitable to be built in into a telephone housing.

The elongated element 14 has been described as functioning as a GPS antenna. It is also possible to provide this antenna so as to function as an antenna for other circularly polarized electromagnetic waves.

The element 14 of the GPS antenna has been described as an elongated, essentially strip-like element. In an alternative embodiment, this element is given a meander shape. In that way, the effective length of the element is extended, thus providing a more compact antenna device.

Alternatively, the element 14 can be provided as a circular wire, thereby simplifying the manufacturing thereof. This wire can be provided with an inner portion extending from a connection point of the PCB and an outer portion bent essentially 90 degrees in relation to the inner portion and having an extension essentially corresponding to the extension of the second element 14 described in connection with the preferred embodiment.

The element 14 of the GPS antenna has been shown positioned in the plane of the ground plane 22. However, the exact position of that element can vary. It can be provided closer to the plane of the first antenna element 12 or even in that plane. Than means that the two

radiating elements 12, 14 can be provided on the same surface of the substrate.

The antenna elements 12, 14 have been shown mounted on an L-shaped substrate 10. It is realized that they can be provided in any suitable way and on any suitable substrate as long as they have the described mutual position described herein.

The feed element of the antenna element 14 has been described as being positioned at one end of the element. It is realized that the position of the feed element can be varied depending on the desired characteristics of the antenna element.

Although the ground plane 22 has been shown with a rectangular shape it should be appreciated that it can take a number of shapes as it constitutes the grounding paths of the PCB 20. However, it is preferred that the upper end portion 22a thereof is essentially straight.

The terms "upper" and "lower" end portions have been used to designate the upper and lower edges of the first radiating element 12 and the ground plane 22 in a preferred operating position. However, with alternative configurations, such as a meander shaped first radiating element, these terms refer to the portions constituting the uppermost and lowermost parts of the element 12 and the ground plane 22 in operation of the device.

Throughout this application, with the expression "internal antenna" or "internal antenna element" is to be understood an antenna or antenna element provided in the housing of a radio communication device or on a

surface of a non-protruding portion of the housing of the device.

CLAIMS

1. An antenna device for a portable radio communication device, comprising:

- a ground conductor (22) being positioned in essentially one plane and having front and back surfaces and an upper (22a) and a lower (22b) end portion,

- a first internal antenna element (12) having a feed portion and an upper (12a) and a lower (12b) end portion, said first element being essentially parallel to, and at least partially overlapping with, and spaced apart from said ground conductor back surface by a predetermined first distance (d1), and

- a second internal antenna element (14) having a feed portion and being spaced apart from said upper end portion (22a) of said ground conductor (22) by a predetermined second distance (d2) and spaced apart from said upper end portion (12a) of said first antenna element by a predetermined third distance (d3),

characterized by

- said second element (14) being elongated and adapted to receive circularly polarized radio signals by operation with linear polarization.

2. The antenna device according to claim 1, wherein said second element (14) is closer to said upper end portion (12a) of said first antenna element

than said lower end portion (12b) of said first antenna element.

3. The antenna device according to claim 1 or 2, wherein said second element (14) is positioned essentially in the plane of said ground conductor (22).

4. The antenna device according to claim 1, 2, or 3, wherein said second element (14) is essentially parallel to said upper end portion (22a) of said ground conductor (22).

5. The antenna device according to any of claims 1-4, wherein said upper end portion (22a) of said ground conductor (22) is essentially straight.

6. The antenna device according to any of claims 1-5, wherein said second element (14) is essentially strip shaped.

7. The antenna device according to any of claims 1-5, wherein said second element (14) is meander shaped.

8. The antenna device according to any of claims 6 and 7, wherein said second element (14) is positioned in a plane essentially perpendicular to the plane of said ground conductor (22).

9. The antenna device according to any of claims 1-5, wherein said second element (14) is wire shaped.

10. The antenna device according to any of the preceding claims, wherein said second element (14) has a length adapted for use with the GPS system.

11. The antenna device according to claim 10, wherein said second element (14) has a length of about 5 cm.

12. The antenna device according to any of the preceding claims, wherein at least one of said first and second elements (12, 14) is provided with a grounding portion.

13. The antenna device according to any of the preceding claims, wherein said feed portions of said first and second element (12, 14), respectively, are connected to separate electronic circuitry.

14. The antenna device according to any of the preceding claims, wherein said first distance (d1) is shorter than said third distance (d3).

15. The antenna device according to any of the preceding claims, wherein said second distance (d2) is shorter than said third distance (d3).

16. The antenna device according to any of the preceding claims, wherein said first antenna element (12) constitutes part of a planar inverted F antenna.

17. A portable radio communication device, comprising:

- a housing (30), and
- a user interface,

characterized by

- an antenna device according to any of the preceding claims provided inside said housing (30).

18. The portable radio communication device according to claim 17, wherein said antenna device is positioned in the upper portion of the radio communication device (30).

19. The portable radio communication device according to claim 18, wherein said second antenna element (14) of said antenna device is positioned in the top of the radio communication device (30).

20. A method of operating a portable radio communication device comprising a ground conductor (22), a first antenna element (12) having a feed portion, and a second elongated antenna element (14) having a feed portion,

characterized by

the step of receiving circularly polarized radio signals by means of said second antenna element (14) by operation with linear polarization.

21. The method according to claim 20, wherein said circularly polarized radio signals are GPS signals.

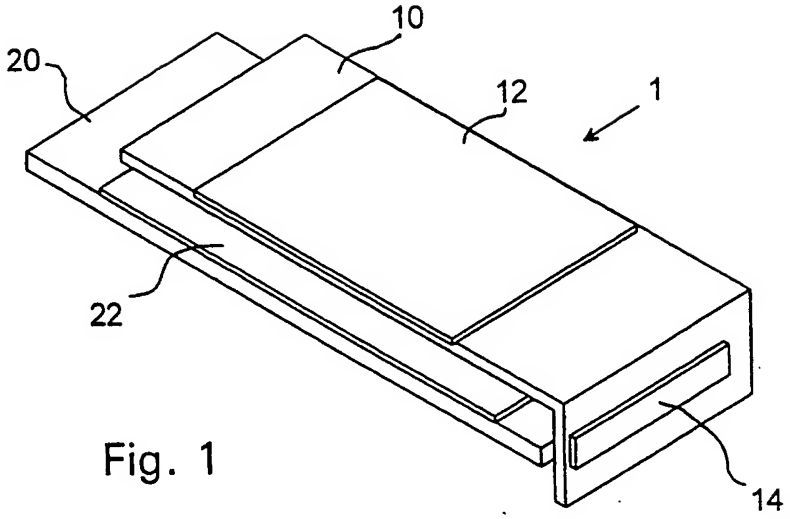

Fig. 1

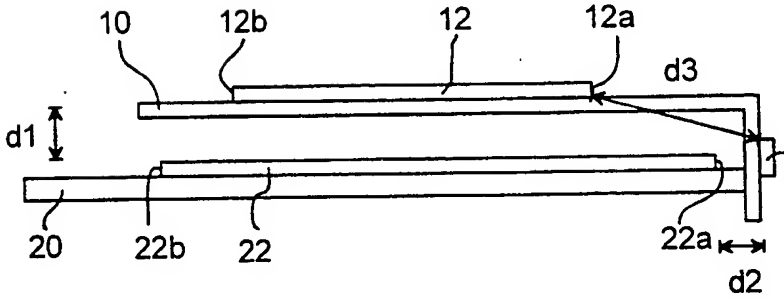

Fig. 2

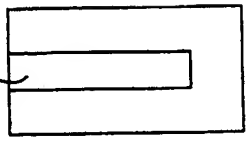

Fig. 3

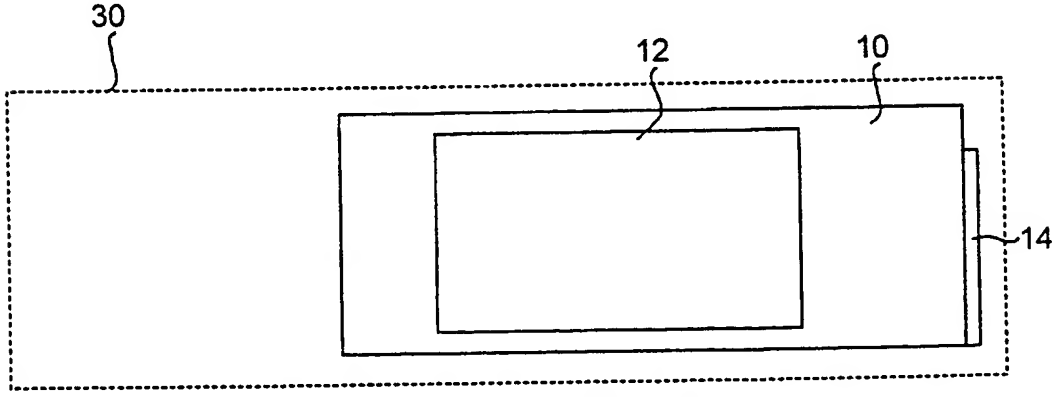

Fig. 4

INTERNATIONAL SEARCH REPORT

Intern. nal application No.
PCT/SE 00/02208

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 1/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0821428 A2 (KYOCERA CORPORATION), 28 January 1998 (28.01.98), column 1, line 12 - line 25; column 3, line 28 - line 42; column 4, line 19 - line 33, claims	1-6,8,10-13
A		2-14,16,17, 19-21
	--	
X	US 5929812 A (AMINZADEH), 27 July 1999 (27.07.99), column 4, line 29 - line 36, figures	1,15,18
A		2-14,16,17, 19-21
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[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"P" document published prior to the international filing date but later than the priority date claimed
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"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer S-E Bergdahl / JA A Telephone No. +46 8 782 25 00

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5444452 A (ITOH ET AL), 22 August 1995 (22.08.95), column 1, line 45 - column 2, line 8	1,15,18
A		2-14,16,17, 19-21

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Information on patent family members

05/02/01

Intern nal application No.

PCT/SE 00/02208

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0821428 A2	28/01/98	CN 1174484 A	25/02/98
		JP 10041740 A	13/02/98
		US 6041220 A	21/03/00
US 5929812 A	27/07/99	DE 19646100 A	14/05/98
		EP 0841715 A	13/05/98
US 5444452 A	22/08/95	US 5323168 A	21/06/94